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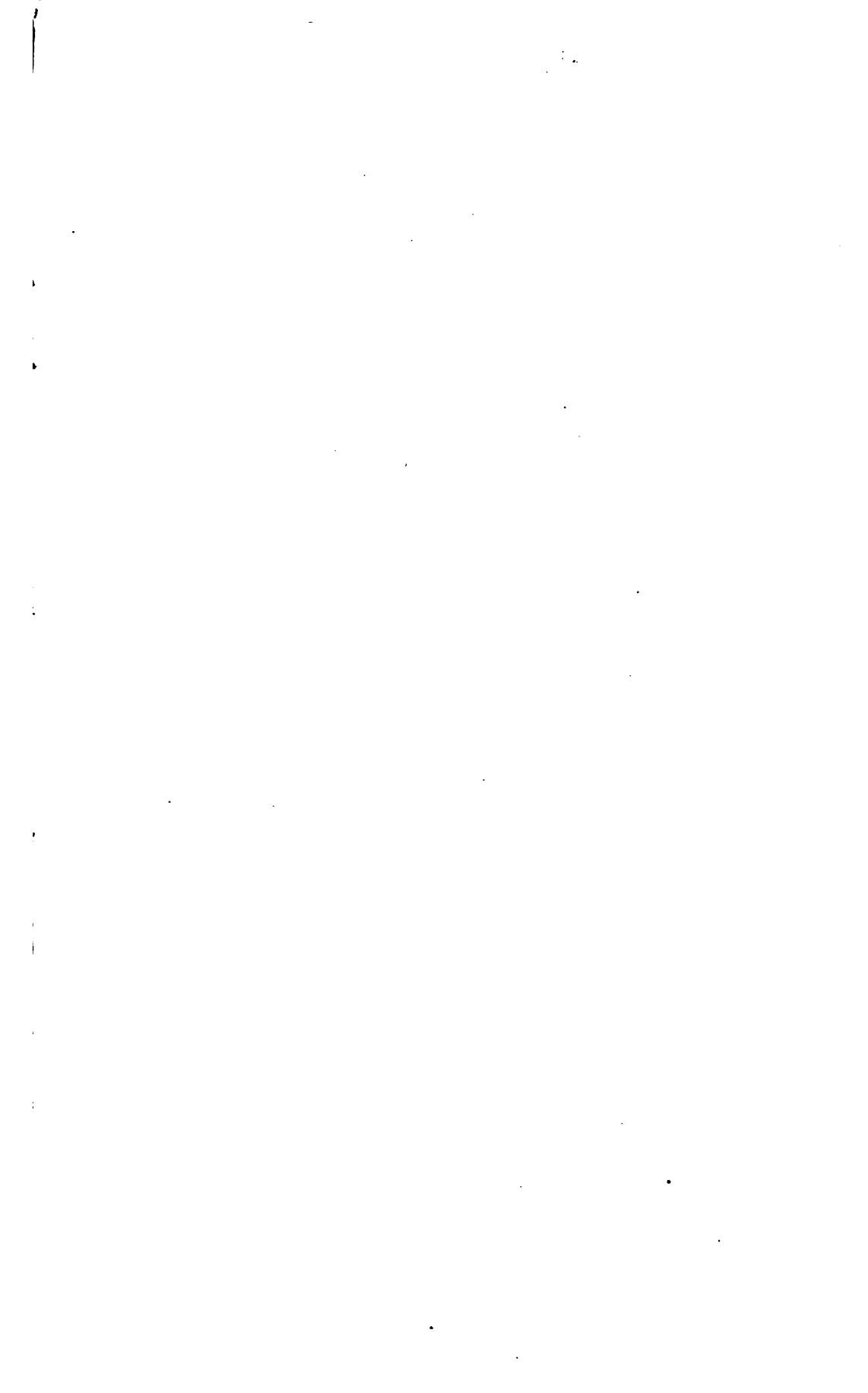


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ON THE  
GEOLOGICAL STRUCTURE  
OF THE  
CENTRAL AND SOUTHERN REGIONS  
OF RUSSIA IN EUROPE,  
AND OF THE URAL MOUNTAINS.

BY RODERICK IMPEY MURCHISON, F.R.S., M.R.I.A.,  
PRESIDENT OF THE GEOLOGICAL SOCIETY OF LONDON,  
GENERAL SECRETARY TO THE BRITISH ASSOCIATION, ETC. ETC.;

E. DE VERNEUIL,  
VICE-PRÉSIDENT DE LA SOCIÉTÉ GÉOLOGIQUE DE FRANCE;

AND

COUNT A. VON KEYSERLING,

BEING A GENERAL SUMMARY OF A SECOND GEOLOGICAL SURVEY  
DURING 1841.

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*[Abstracted from Memoirs read before the Geological Society of London,  
April 1842.]*

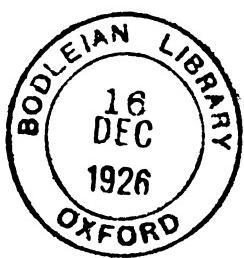
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LONDON:

PRINTED BY RICHARD AND JOHN E. TAYLOR,  
RED LION COURT, FLEET STREET.  
1842.

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PART I.

ON CENTRAL AND SOUTHERN RUSSIA.

WITH the exception of a sketch of the Ural Mountains, to be given in a subsequent memoir, and of two short notices previously read, on the Freezing Cave of Iltežkaya Zatchita, and on the "Tchornoi Zem," or Black Earth\*, the following abstract contains the chief results of a second examination of Russia in Europe. Following the same method as in the account of their first examination, the authors describe the depositary strata in ascending order, successively adding to or correcting their previous knowledge of each mass of deposits.

*Silurian Rocks.*—The boundaries of these the most ancient fossiliferous strata are more correctly defined than last year, and new localities are cited. The lowest subdivisions of blue shale and unguilite grit, which were previously spoken of in certain inland spots only, are now described in the sea-cliffs of the Baltic between Reval and Narva, as well as on the banks of the rivers Narva and Luga, in which situations, as in the tracts S. and S.E. of St. Peters-

\* See Proceedings Geol. Soc. London, pp. 712-714.

burgh, they constitute the inferior masses or representatives of the Lower Silurian Rocks.

The Upper Silurian Rocks, chiefly composed of thin-bedded limestone, occupy the summits of the coast-cliffs in question, and the platform on which the river Narva flows from the lake Peicpus to a chasm worn by its own action, where it constitutes the picturesque falls above the Castle of Narva. It is believed by the authors that this water-fall has receded (like those of Niagara, in America, and other places,) in consequence of a solid tabular rock overlying less coherent strata, which have been undermined and have occasioned the subsidence of the superior layers. In addition, however, to these conditions, the wearing away of the vertical cliffs of the Baltic and the retrocession of the falls of the Narva, are supposed, by the authors, to have been accelerated by another cause, viz. the direction of the symmetrical joints in the overlying limestone. These joints present a number of salient and re-entering angles which are exposed on the surface of the impending cliffs, and when the softer supporting strata have been partially excavated, the dividing lines of these natural joints facilitate the fall of the calcareous beds into the abyss below.

Besides the chief masses of limestone which extend over a considerable tract in the province of Esthonia, (including the Isles of Oesel and Dago,) the authors advert to a separate tract near the small town of Schavli, in the government of Wilna, occupied by upper Silurian rocks, which they discovered in their journey to St. Petersburg, and which they place as the highest member of the system, or above the principal masses of the Orthoceratite and Trilobite limestone and beneath the overlying old red or Devonian formation. In this limestone fifteen species of fossils were observed, including *Pentameri*, *Terebratulae*, and *Orthidæ*; and it is considered to be the representative of a calcareous rock which ranges to the north of Dörpat and Weissenstein, and is known at Oberpahlen, &c. Notwithstanding their almost perfectly horizontal position, the strata in the Baltic provinces of Russia indicate most clearly a passage from a lower horizon on the north to a higher on the south, where they are surmounted by the Devonian system.

In announcing a large accession of Silurian fossils to their former lists, the authors advert to the labours of Professor Eichwald,

who after a personal examination of the coast-cliffs and of the Isle of Dago, has been sedulously occupied in describing many new species. They also dwell upon the important addition to their knowledge of new forms contributed by Dr. Wörth, the secretary of the Imperial Academy of Mineralogy,—forms which they purpose to figure and describe in the course of the ensuing winter; and they acknowledge their obligations to Colonel Helmersen and the officers of the School of Mines, for aiding them in their acquisition of fresh knowledge concerning the contents of these the most ancient deposits of the Russian empire. In their tabular list of fossils the authors give the following as characteristic of, and in part peculiar to, the Silurian rocks of Russia :—

*Asaphus expansus* (Dalm.\*), *A. cornutus*, *Illanus crassicauda* (Dalm.\*), *Amphyx nasutus* (Dalm.\*), *Orthoceratites vaginatus* (Schloth.†), *Lituites convolvens* (Schloth.†), *Clymenia Odini* (Eichw.‡), *Terebratula Wilsoni*<sup>1</sup> (Sow. in Sil. Syst.), *T. sphæra* (Von Buch§), *T. camelina* (Von Buch§), *Orthis anomala* (Terebrat. Schloth.†), *O. Uralensis*<sup>1</sup>, n.s., *O. Panderi*, n.s., *O. cincta* (Eichw.‡), *Leptaena imbrex* (Pand.), *Leptaena rugosa* (Dalm.||), *Spirifer biforatus* (Terebrat. id. Schloth.), *S. lynx* (Eichw.‡), *S. æquirostris* (Terebr. Schloth.), *S. porambonites* (Von Buch§), *Pentamerus Vogulicus*<sup>1</sup>, n.s., very near to *P. Knightii* (Sil. Syst.), *Crania antiquissima*, nob. (*Orbicula antiquissima*, Eichw.‡), *Lingula quadrata* (Eichw.‡), (*L. Lewisii*, Sil. Syst.), *Ungulites* (Pand.¶), *Obolus* (Eichw.), *Spheronites aurantium* (*S. citrus*, His.\*\*), *Hemicosmites pyriformis* (Von Buch), *Catenipora labyrinthica* (Gold.††), *Favosites Gothlandica*<sup>1</sup>, †† *Favosites Petropolitana*, *Graptolites*, &c.

*Devonian Rocks* (Northern Zone).—By visiting Livonia and Courland some essential points of interest were added to the knowledge

\* Om Palæaderna eller de sa Kallade Trilobiterna. Stockholm, 1828.

† Die Petrefactenkunde der Vorwelt. 8vo. Götha, 1820.

‡ Sur le Système Silurien de l'Estonie. 8vo. St. Petersbourg, 1840.

§ Beiträge zur Bestimmung der Gebirgsformationen in Russland. 8vo. Berlin, 1840.

|| K. Vet. Acad. Handl. 1827.

¶ Beiträge zur Geognosie des Russischen Reiches. 4to. St. Petersburg, 1830.

\*\* Lethæa Suecica. 4to. Holmiae, 1837.

†† Petrefacta Germaniæ. 1ter Thiel. fol. Dusseldorf, 1826—1833.

†‡ Lamarck, Animaux sans Vertèbres, tome 2. 8vo. Paris.

1 The fossils marked (!) occur in the Ural mountains only.

which the authors had previously obtained of the relation and contents of the old red or Devonian series. The central districts of Courland have been, for the first time, proved to contain rocks of this age charged with typical fossils, both fishes and shells. A section of the Düna river above Riga which exhibits some undulations of the strata, exposes siliceous limestones, subordinate to red and greenish shale; whilst the country between Riga and Dörpat is occupied by sands and marls. M. Pander, who now resides in this district, has collected a large and instructive series of its organic remains, chiefly from the banks of the river Aa; and among the Ichthyolites which they obtained from him, the authors recognised remains of *Coccosteus* and *Holoptychius* similar to those previously collected by them in the Waldaï Hills, and which Professor Agassiz has identified specifically with forms described by him from the old red sandstone of Scotland. Professor Owen has also identified among teeth from the collection of M. Pander, two or more varieties of the genus *Dendrodon* (Owen), equally characteristic of the old red sandstone of Scotland, one of them being indeed undistinguishable from the *Dendrodon* of that author, described from specimens found at Scat's Craig near Elgin.

In the marls and sands of Dörpat, Professor Asmus of the University at that place has collected and is describing certain gigantic bones, which were formerly supposed to belong to Saurians, but which, by their analogy to existing skeletons, he has shown to belong to fishes\*. A single bone of one of these remains is nearly three feet long, and according to the estimate of Professor Asmus, the Ichthyolite of which it is a part must have had, when entire, a length of not less than thirty-six feet. The union of these fishes, some of the species of which, as above stated, are typical of the old red sandstone of the British isles, with numerous fossil shells which have been found to characterize the beds of the Devonian age in England, Belgium, and the Boulonnais (an union was pointed out last year as resulting from an examination of the provinces of St. Petersburg, Novogorod, Olonetz, &c.), is now more amply con-

\* At the request of Mr. Murchison, Professor Asmus has prepared and sent to England duplicate casts of these the most remarkable and most gigantic fossil fishes ever yet discovered. One set of these has been given by Mr. Murchison to the British Museum, another to the Geological Society of London, and a third to Professor Agassiz.

firmed by reference to the structure of the north-western governments of Russia, through which the same system is spread.

*Southern Zone of Devonian Rocks, or Geological Axis of Russia in Europe.*—Previous to their visit to the central and southern regions of Russia, the authors believed, in common with their precursors, that the ascending order of the strata was continuous from the Baltic provinces on the north to the Black Sea and Sea of Azof on the south, with the exception only of the granitic rocks and carboniferous tracts of the southern steppes. They were undeceived, however, by discovering in the heart of Russia (Orel, Voroneje, &c.) a great domelike elevation, which is composed of rocks loaded with Ichthyolites and Mollusks, all eminently characteristic of the Devonian system\*. This mass sinks to the north under a great band of carboniferous rocks (Tula, Kaluga, &c.), the northern part of which was last year described as occupying the territory around Moscow and extending thence north-eastwards to the neighbourhood of Archangel : to the south it is lost under younger accumulations of secondary age. The dome of palæozoic rocks rising to an altitude of about 800 feet above the sea, was thus found to divide Russia into two distinct geological basins, viz. that of the carboniferous limestone of Moscow on the north, and that of the Jurassic, cretaceous and tertiary deposits on the south. One of the most remarkable features of this central mass consists in the lithological character of its rocks, as contrasted with that of formations of the same age, and containing the same fossils, in the northern governments ; for whilst the latter in their range from the western borders of Lithuania to Olonetz and Archangel, including part of the Walday Hills (see last year's memoir, *ans*, p. 401), are invariably made of sands, sandstones, marls, and impure limestones, of prevailing red and green colours ; their equivalents in Orel and Voroneje are yellow and white marlstones and limestones, the latter often

\* A part of the tract between Orel and Lichwin was examined by Colonel Helmersen during the same summer, and before the visit of the authors, and he also recognised the existence of Devonian rocks. The authors, however, were quite unaware of this circumstance when they first published their views on this point at the end of September 1841, in a letter addressed to Dr. Fischer de Waldheim, and it was on their arrival at St. Petersburg only, that they found that Colonel Helmersen had come to the same conclusions as themselves, in respect to a portion of the country in question.—See *Bulletin de la Société Impériale des Naturalistes de Moscou*, Oct. 1841.

in the state of magnesian limestone, and resembling in external aspect the Zechstein of Germany or the rocks of Sunderland in the British Isles. In addition to the characteristic fossils, enumerated last year from the great northern Devonian region, the central masses, particularly at Voroneje, have afforded many shells which have been published as typical of strata of the same age in Western Europe, such as *Spirifer Archiaci*, *S. Verneuilii*, *Leptaena Duterrii*, *Productus productoides*, of the Boulonnais\*, together with *Orthis crenistria*, *Productus spinulosus*, and *Aulopora Favosites*, and other polypifers. It is indeed very remarkable, that in countries so distant from each other as the central region of Russia and the Boulonnais, twelve species at least of the fossils found at Voroneje should prove to be common to the rocks of the same age in both localities, and that in both instances the order of superposition should be so clear. The superior value, however, of the Russian sections of this division of the Palæozoic rocks over those in every other part of Europe, consists in the conjunction before adverted to and so generally observed in Russia, of *Holoptychius* and other fishes of the old red sandstone of Scotland and England, with the fossil shells characteristic of South Devon, the Boulonnais, and the Eifel †.

*Carboniferous Limestone and Coal.*—The lowest beds of the carboniferous system in Russia are, as stated in our first abstract, p. 8, sands and shale with thin seams of coal, *Stigmaria ficoides*, &c. The authors examined a considerable tract occupied by these beds to the south of Tula and Kaluga, where many additional natural outcrops have been discovered by Colonel Olivieri, the mineral having the lignite or impure character of the beds of coal described last year in a similar position in the Waldaï Hills. These strata are, the authors conceive, of the same geological age as those of the great productive coal-field of Berwickshire, which equally underlies the mountain limestone.

By their recent labours the authors have divided the carboniferous limestone of Russia into three members. The lowest of these,

\* See Mr. Murchison on the Boulonnais.—*Bulletin de la Société Géol. de France*, tome xi.

† The large scales of *Holoptychius Nobilissimus* were found by the authors at a locality called Kipet between Lichwia and Bielef.

generally a dark-coloured rock, is characterized by the presence of *Productus giganteus* and *P. Waldaius* (near to *P. anomala*, Sowerby, &c.). The central mass is the well-known white limestone of Moscow, containing *Spirifer Mosquensis*, *S. resupinatus*, *S. glaber*, the *Chætetes radians*, *Euomphalus pentangulatus*, and many other fossils, some of which (such as *Productus antiquatus*, *P. comoides*) are found also in the lower division. Beds of compact, yellow, magnesian limestone occur in this central part of the carboniferous system, as well as bands of red and greenish shale or marl, and thin beds of pure siliceous flint graduating into ordinary limestone chert.

The third calcareous division is one which is not seen in the Wal-dai or Moscow district, but which seems to surmount the before-mentioned divisions on their eastern flank at Velikovo and Kosrof, on the river Kliasma. Again, the lofty cliffs which occupy the banks of the Volga between Stavropol and Samara are almost exclusively composed of this member of the carboniferous limestone, which is there made up of myriads of *Fusulinae* (the fossil bodies mentioned by Pallas as resembling grains of wheat), associated with *Euomphalus pentangulatus*, *Cyathophylli*, &c.

In a part of the coal region between the Dnieper and the Don, the authors detected a band of this *fusulina* limestone, in the same relative position which had been assigned to it in other parts of Russia, namely, in the upper part of the calcareous strata.

*Carboniferous Region between the Dnieper and the Don, or Coal-field of the Donetz.*—Whilst the central member of the carboniferous limestone of the northern parts of Russia (Moscow basin) contains no coal, and the upper beds on the Volga are equally void of it, rocks of the same age in the South of Russia, or on the banks and in the neighbourhood of the river Donetz, are in parts eminently productive of good bituminous as well as anthracitic coal. Among the sections described, one from Karakuba, on the river Kalmius, to the neighbourhood of Bachmuth, shows a regular succession, in ascending order, from beds of conglomerate and red sandstone, forming the base of the carboniferous system, through various bands of limestone, alternating with many courses of sandstone and shale with numerous seams of coal.

In this wide carbonaceous tract, coal is extracted by the imperial government at two spots only. These pits were first opened in

the last century, by Mr. Gascoigne and a small company of English miners, formerly employed by the Russian government. The shaft section at Lissitchi Balka, the chief of these places, and situated to the north of the iron foundries of Lugan and to the east-north-east of Backmuth, clearly shows that all the best seams of coal of this tract are subordinate to the central part of what English geologists call the mountain limestone. Including small and profitless seams, twelve beds of coal occur at this locality, seven of which are extracted for use. The greater part of the coal is of fair quality, and some is exceedingly good and chiefly bituminous; and all these beds, with a great amount of shale and sandstone occupying a thickness of 800 English feet, are interlaced with thin courses of limestone, which are charged with *Spirifer Mosquensis*, *Productus antiquatus*, *Orthis lata*, *O. planissima*, *Bellerophon*, *Turritella*, *Pecten*, *Nautilus*, and a small Trilobite, thus leaving no doubt that the coal is subordinate to the same series of beds which in the North of Russia, beyond the great Devonian axis before described, is void of the mineral, and yet contains the same fossils. In examining these tracts of coal, the authors perceived a close analogy between them and those of the North of England. In the South of England, as in the North of Russia, no coal occurs in the lower or calcareous division of the system; but in Yorkshire, Durham and Northumberland sandstone and shales are interpolated and the mountain limestone is expanded, as on the Donetz, into a great complex series (Yoredale Rocks of Phillips), including seams of coal.

In the mineral composition of this carboniferous tract there is a striking analogy to the condition of the great British coal-field of South Wales; for one end of the tract contains anthracitic, and the other bituminous coal, though the strata are, it is believed, of the same age. In the Russian case, the anthracitic masses occupy the eastern end of a tract, the major axis of which trends from west-north-west to east-south-east, and the bituminous coal is on the west. In the tract where the anthracite prevails, the limestone seems to thin out, and there are consequently fewer fossils.

Unlike the flat and untroubled regions of northern and central Russia, this carboniferous tract is often highly dislocated, and is everywhere thrown into broad and rapid undulations. In the chief mines at Lissitchi Balka the strata dip about  $20^{\circ}$ , and are there-

fore easily worked and drained; but at Uspenskoi, near Lugan, the beds, which are neither so numerous nor so good as at the former place, are inclined at  $50^{\circ}$ , and even at  $70^{\circ}$ , and are full of extensive faults.

The carbonaceous strata (often worked by the small proprietors and Cossack and Russian peasants) are described in several places, and the same geological relations are shown to prevail, the coal beds being stated in all cases to be subordinate to the mountain limestone series, whilst certain overlying shales, sandstones, &c., which were observed in one corner of the district, contain few or no traces of coal.

At the western extremity of this region, the coal-bearing strata thin out into sandy masses, which repose unconformably on certain highly inclined quartzose, gneiss and granitic rocks, that appear on the banks of the river Voltchia, and extend to the Dnieper and the cataracts of that river near Ekaterinoslaf. To the south-west, near Karakuba and towards Mariopol, in a tract occupied by Greek colonies, similar primary rocks appear, penetrated both by granite and porphyry, whilst to the south-east and north the whole carbonaceous region is overlapped partially by red sandstone with gypsum, as near Bachmut, but more generally by cretaceous and tertiary rocks. The former, in the state of white chalk, occurs in a large zone in the north, and in a smaller band at the southern limits of the coal tract.

The dislocations and upheaval of the subjacent rocks extend to some distance to the north of the chief carbonaceous masses; for at Petrofskaya, considerably to the north of the nearest outcrop of the chief coal field, coal with carboniferous limestone is upcast to the surface in highly inclined positions, surrounded by nearly horizontal strata of the Jurassic and cretaceous epochs, and generally so obscured by drift and clay, that it is well seen in one ravine only. Coal, however, has been detected at adjacent places in sinking for water.

The uppermost members of the carboniferous system are not observable in the North of Russia, or in the Moscow basin, where Jurassic strata repose at once upon true carboniferous limestone; but in the southern coal-tract, just alluded to, there are, as before said, beds of shale and sand which overlie this limestone series, and yet are unproductive of coal (north of Gorodofka). On the western

flanks of the Ural mountains, however, as will be shown in the next memoir, to the east of Perm, and at Artinsk, are sandstones and conglomerates with plants passing occasionally into calcareous grits with Goniatites, which, as seen on the banks of the Tchussovaya and near Artinsk, are superior to the great carboniferous limestone. Very thin courses of coal only are observed at intervals in this upper member of the system, and the Goniatites which it contains belong, as a whole, to that division of the family which characterizes the uppermost member of the carboniferous limestone and certain coal-fields (Coalbrook Dale) of Western Europe. There is a considerable development of this subdivision on the flanks of the Gubertlinski hills, and partially on the south-western edges of the Ural, east of Orenburg.

*Permian System. (Zechstein of Germany—Magnesian limestone of England.)*—Some introductory remarks explain why the authors have ventured to use a new name in reference to a group of rocks which, as a whole, they consider to be on the parallel of the Zechstein of Germany and magnesian limestone of England\*. They do so, not merely because a portion of the deposits in question has long been known by the name “grits of Perm,” but because, being enormously developed in the governments of Perm and Orenburg, they there assume a great variety of lithological features, and contain the bones of thecodont Saurians and certain fishes, also a more copious fauna and flora than have ever been observed in their equivalents in Western Europe.

The Permian rocks of Russia which occupy so vast a region to the east of the river Volga, i.e., in the governments of Kasan, Viatka, Perm and Orenburg, are composed of white limestone with gypsum, red and green grits with shales and copper ores, magnesian lime-

\* “ I have recently been informed by M. A. Erman, that an erroneous view has been communicated in my anniversary discourse, respecting the first use of the word ‘Zechstein’ in reference to the deposits of Perm, that term having been used, as he assures me, by German miners, who visited Russia long ago, though no proofs have been since offered to sustain its application in a geological sense. I also take this opportunity to state, that through a misapprehension of his views, derived from a perusal of the Bulletin de la Société Géologique de France, I have been led into a mistake in supposing that M. Erman believed a large portion of the Russian rocks, now shown to be carboniferous, to belong to the Jurassic epoch. I willingly adopt this correction of my views in reference to the distinguished modern explorer of Siberia and Kamschatka.”—R. I. M., Sept. 1842.

stones, marl-stones, small conglomerates, red and green sandstones, &c. By examining numerous natural sections between the neighbourhood of Sviask, Kasan, and Samara, upon the west, and the carboniferous limestone on the edge of the Ural mountains on the east, the authors have come to the conclusion, that however the lithological sequence may vary in different tracts, the whole of the vast region alluded to is occupied by deposits which belong to one class or zoological system of deposits. Thus, though the limestones are sometimes white, sometimes yellow and pure magnesian, and oftentimes pass into marl and marlstone, all of which can be observed to inosculate with strata of red sandstone, conglomerate, &c., the same fauna pervades the whole group. The Mollusca and Polypifers are clearly of a type intermediate between those of the carboniferous limestone and those of the Trias or new red sandstone group of Continental geologists. Among the most characteristic of these fossils may be enumerated *Productus horrescens*, n.s., *P. Cancrini*, n.s., *Spirifer lamellosus* (L'Ev.), *Terebratula elongata* (Schloth.), *T. Roysii* (L'Ev.) (*T. Roysii*, L'Ev. = *Atrypa pectinifera*, Sow. Min. Conch. No. 107), *Natica variata* (Phil.), *Modiola Pallasii*, n.s., *Gervillia lunulata* (Phil.), *Ostraea matrcula*, n.s., *Corbula Rossica*, n.s., *Avicula Kasaniensis*, n.s., *A. antiqua* (Schloth.), *A. cheratophaga* (Schloth.), *Lingula parallela* (Phil.), *Limulus oculatus* (Kutorga), *Cytherina*; with *Retepora flustracea*, *Gorgia*, *Millepora*, &c. &c.

In the conglomerates and sandstones, fishes have been found, some of which belong to the genus *Palaeoniscus*, so characteristic of the Zechstein and magnesian limestones; and the Saurian bones, portions of which have been figured by M. Kutorga, and more perfect remains of which have been described by Professor Fischer von Waldheim (*Rhopalodon Mantellii*, Fisch.), have been pronounced by Professor Owen to belong to the class of thecodont Saurians of that author (See Report on Saurians to the British Association, 1841, p. 159).

Certain plants of this great deposit have been figured by M. Kutorga, and referred by him to the carboniferous epoch; others collected by Major Wangenheim Von Qualen have been named by M. Fischer de Waldheim, who, as well as their discoverer, felt great difficulty in forming any decisive opinion respecting the age of the strata in which these fossils occur. Having examined the localities

and sections, the authors convinced themselves on the spot, that all these plants are of intermediate character between those of the carboniferous and triassic æras\*. These vegetables of the Permian system, and many undescribed species of shells with which they are associated, will be figured in a forthcoming work on the geology of Russia, and for this purpose M. Fischer has kindly contributed some beautiful drawings of new genera and species which he had prepared at Moscow.

The publication of these new species will show that the epoch of the Zechstein was characterized by a flora peculiar to it. These fossil plants, although generally appearing to constitute an independent flora, offer some analogies in form to a few species belonging to the carboniferous series : one species cannot easily be distinguished from the coal-measure plant, *Cal. Suckowii*, which Brongniart considers to be very variable in form and to have a great geographical range. Among the characteristic forms may be mentioned the *Calamites gigas*, *Neuropteris Wangenheimii*, *N. salicifolia*, *Odontopteris Stroganovii*, *Sphenopteris erosa*, *Noeggerathia undulata*, and some other species to be described.

These plants are sometimes accompanied by thin courses of coal and lignite, which near Perm have some of the external characters of poor coal-fields. But while the carbonaceous appearances are evanescent and local, the fossil stems and leaves are very general indicators of the presence of copper ore, which, in the form of grey oxide and green carbonate, is often copiously disseminated through the vegetable matter, or arranged around the thicker branches in masses, from which it extends in fine filaments into the adjacent sands or marls. In all cases, the copper ores of this region occur in laminae, inosculating with the other regular strata, in which respect they differ essentially from the chief copper ores of other countries. They are, in fact, regenerated ores, formed, it is conceived, by cupriferous streams and currents that flowed from the adjacent Ural mountains, which, it will be shown, were, during very early periods, the site of great copper veins†.

\* Mr. Morris, who has undertaken the description of the new species of these plants, completely confirms the views of the authors. (See letter of Mr. Murchison, dated Moscow, October, 1841. Phil. Mag. vol. xix. p. 418.)

† Among the mineral analogies between the Permian rocks and those of

As a solution of copper which was let loose by accident in modern times upon an adjacent peat bog in North Wales specially affected and impregnated the vegetable fibre in preference to the accompanying soil, so is it conceived that the forests washed into the sea in which the Permian deposits were accumulated, attracted around them the cupriferous matter contained in the transporting currents. This point will be reverted to in the subsequent sketch of the Ural mountains.

The general succession of these Permian deposits is then described on several parallels of latitude between the Ural and the Volga, and also their outliers in the steppe between Orenburg and Sarepta ; and it is shown, that this vastly extended and diversified system, containing not only copper deposits but also large masses of gypsum, rock-salt and copious salt-springs, lies in an enormous trough bounded on the north and east, and south-west, by the carboniferous limestone on which it reposes.

By their examination during the past year, the authors have cleared away some difficulties which obscured their former views. By reference to the abstract of their first memoir (p. 8), it will be seen, that they considered (though with much hesitation) certain limestones and beds of gypsum which occupy cliffs upon the Dwina to the south of Archangel, and extend to Pinega and towards Ust Vaga, to be upper members of the carboniferous limestone. By a comparison of the *Producti* and other fossils, and the great masses of gypsum which they contain, these northern beds are now brought into direct identification with the true Permian or Zechstein deposits. In the south-western termination of this vast basin near Samara, the Permian rocks, particularly at Usolie, rest in patches of a dolomitic conglomerate upon the steep escarpments of the carboniferous limestone, out of the materials of which they have been formed, and do not present that regular succession which they exhibit when followed westwards

the magnesian limestone it appears, from Professor Sedgwick's description of the latter, that traces of lead ore and also of copper, are found in it in small quantities, which that author considers to have been derived from the large mineral masses of the same in the surrounding and more ancient carboniferous limestones. Lead is also worked in the dolomitic conglomerate of the Mendip Hills, where it is associated with calamine. See memoir of Mr. Conybeare and Dr. Buckland, Geol. Trans., 2nd Series, vol. i. part 2. p. 293 ; also Mr. Weaver's memoir, *ibid.* p. 367.

from the slopes of the Ural chain. It is also observed, that though gently undulating or horizontal over all the lower regions, these rocks, on approaching the Ural mountains, are occasionally thrown into anticinal axes of some length, parallel to the direction of the palæozoic rocks of the adjacent chain.

In a sketch of the outliers in the Steppe of the Kirghiss, the base of the insulated hill of Monte Bogdo, is shown to consist of a member of the Permian group, surmounted by fossiliferous limestone, which probably belongs to the Jurassic system; and it has before been shown that the rock-salt of Iltetzkaya Zatchita\*, south of Orenburg, is subordinate to this system, in which indeed the greatest saline springs of Russia occur.

*Red Sandstone, Marl, &c.*—It is with hesitation that the authors make any separation between the Permian deposits and certain red and green sandstones, marls, marlstones and tufaceous limestones, which occupy the central parts of the great trough above described; still less can they strictly identify them with the bunter sandstein, new red or trias of West Europe.

It is however a fact, that the Permian rocks with their peculiar fossils are seen near Sviask, on the west of Cazan, to pass under red and green marls and impure limestones, which extend over a wide region by Nijny Novgorod, Juriavetz and Viasniki on the west, and to Totma and Ustiug on the north. In no part of the region so defined (and most of which the authors examined on a previous occasion), have any fossils typical of the Permian age been discovered, though the deposits in question abound in limestones generally of a tufaceous character. The gypsum which occurs in this member, differs from the massive white alabaster of the inferior rocks, and is usually in the form of small concretions of fibrous structure, often of brownish and pinkish colours. At only Viasniki on the Kliasma could the authors detect any traces of fossils, and these are minute *Cyprideæ*, associated with apparently flattened *Cyclades?* which are imbedded in blood-red marl. The thick cover of detritus which is spread over a very large area, obscures the junction of these red deposits with the eastern edges of the carboniferous limestone of the Moscow and northern regions. Whatever may be the precise age of the uppermost beds of these

\* Proceedings Geol. Soc. London, vol. iii. p. 695.

red deposits in reference to other strata in Europe, it is clear that a considerable portion of the full geological succession is wanting in Russia, for in various points upon the Volga, Jurassic shales are seen to repose on the denuded surface of these red deposits.

*Jurassic System.*—In the sketch resulting from their survey in 1840 (first abstract, p. 9), Mr. Murchison and M. de Verneuil were disposed to view certain deposits of shale and sand with concretions, which in some places overlie the last-mentioned red deposits, and in others rest at once on the carboniferous limestone, as the equivalents of the lias and lower oolites. This opinion is now modified, a more extensive survey having led to the belief that true lias does not exist in Russia; but that the shale beds in question, whether studied in sections on the Moskwa near Moscow, on the Volga between Kostroma and Jurievetz, or at numerous localities in the governments of Simbirsk, Saratof and Tambof, are truly the equivalents of the strata from the inferior oolite to the Kimmeridge clay, inclusive, of English geologists.

It is this jurassic group which is traceable at intervals so far to the north-east, and which has been found by Capt. Strajesski as far as even 65° N. lat. on the eastern flanks of the Ural chain.

The upper members of the Jurassic system, as exhibited in the South of Russia, near Izium, where they were first recognised by Major Blöde, differ both lithologically and zoologically from the dark shales and sands of the northern and central regions. They are chiefly light-coloured limestones and marls, and are charged with large Ammonites resembling those of the Portland rock with *Trigonia clavellata*, *Nerinea*, and other types closely allied to those which occur in the upper oolites of Great Britain and the Continent.

*Cretaceous System.*—This system is very considerably developed in the central and southern tracts of Russia. In the government of Simbirsk, where it has been closely studied and its fossils carefully collected by M. Jasikof, it surmounts the Jurassic series, and the same order may be seen in the governments of Sarátof and on the banks of the Donetz near Izium.

Though the lithological sequence of the strata differs from that of the British Isles, the system, as a whole, bears striking analogies to that of the same age in Western Europe. The white chalk, for example, and many of the fossils which it contains, including *Ino-*

*ceramus* *Cuvieri*, *Belemnites mucronatus* and *Gryphaea vesiculosus*, is absolutely undistinguishable from that of France and England; but in the localities seen by the authors, it did not offer the same subjacent succession of gault and lower greensand, as in Western Europe, though at Kursk the white chalk reposes on hard concretionary sandy ironstone, somewhat resembling the clinkers of the lower greensand of England. Nor are there any evidences of the existence beneath the cretaceous rocks of the "Système Néocomien" of the French geologists. Associated however with the white chalk, the authors observed, particularly between Sarátov and Tzaritzin, many beds of marl and siliceous clay-stone, in which bodies like *Alcyoniae* were prevalent, and at Kursk they found that the white and yellowish subcalcareous marls which closely overlaid the white chalk contained a Belemnite, as well as certain polypifers common to the true white chalk of other parts of Russia (Volsk), and hence they concluded, that some of these overlying marls are possibly the representatives of the Maestricht beds of Europe.

The white chalk alone has been pierced to a depth of upwards of 600 feet by an artesian shaft at the iron forges of Lugan, in Southern Russia, in which tract the deposit lies unconformably on the uplifted edges of the carboniferous rocks.

*Tertiary Deposits.*—The tertiary strata, as separated from diluvial and alluvial accumulations, are little known in the North of Russia, with the exception of the shelly strata of post-pliocene age which have been described in the government of Archangel (Abstract of first memoir, p. 10).

The lowest tertiary beds which the authors personally examined, are the marls with concretions forming cliffs at Antipofka, on the right bank of the Volga below Sarátov, where they were first noticed by Pallas. Among these shells are several species undistinguishable from those published by Sowerby from the London clay of Bognor and Hants, such as *Cucullaea decussata*, *Venericardia planicosta*, *Calyptraea trochiformis*, *Crassatella sulcata*, *Turritella edita*, &c.

The middle tertiary or miocene strata are spread, it is well known, over large tracts in Volhynia and Podolia, in which countries they have been described or alluded to by Prof. Eichwald, M. Dubois de Montpereux, Major Blöde, and others. Distinctions are, however, drawn between the more ancient tertiary strata, such as those of

Antipofka and other places, and the recent Caspian shelly sands which cover the Steppes, the former having constituted a portion of the ancient shores of a more widely spread Caspian sea. The authors also entirely discard from residuary phænomena due to the presence and retirement of these Caspian waters, the existence of certain great subterranean masses of rock-salt and salt-springs which issue from the bowels of the earth, both of which have their seat in purely marine deposits of much higher antiquity, chiefly Permian, and which can never be referred to the desiccation of comparatively modern, brackish, inland seas.

The pliocene and post-pliocene strata occupy a very large region in Southern Russia. The inferior division of this group is well exposed in the lowest part of the cliffs at Taganrog, on the sea of Azof, where beds of white and yellow limestone contain several species of Cardium, a Buccinum and large Mactræ, all of marine origin. The superior members, often reposing on sands and siliceous grits, constitute the widely spread "Steppe limestone," in which are many remains of Mollusca that must have lived in brackish seas.

These beds, as seen at Novo Tcherkask, the capital of the Don Cossacks, and adjacent places, are considered to be the extension of similar shelly deposits in the Crimæa and the neighbourhood of Odessa, described by M. de Verneuil (See Trans. Geol. Soc. of France, vol. iii. p. 1).

The vast flat steppes of Astrachan traversed by Count Keyserling, who rejoined his companions at Sarepta, are proved, as suggested by Pallas, to have been the abode of the adjacent Caspian Sea at a comparatively modern period; and in confirmation of this view, it is stated, that not only the low country is covered with shells, but that the cliffs of Monte Bogdo, which rise out above this steppe, are also corroded to a certain height in the same way as sandstones of similar nature are affected by the surge of the present seas.

*Superficial Detritus, Bones of extinct Mammalia, Northern Boulders, &c.*—It is shown that the mammoth alluvia are analogous to those of other countries in indicating, over large areas, a period when elephants, rhinoceroses and other gigantic animals of species now extinct, inhabited the surface of the earth not far from the spots where they are now interred, their bones, as demonstrated by their condition as well as by the matrix in which they lie, not having un-

dergone distant transport. This subject will be again considered in a sketch of the Ural mountains, but in the mean time, lists of the animals, some of them peculiar to Russia, which are preserved in the museums of Moscow and St. Petersburgh, were given.

Lastly, new data are offered in respect to the southernmost limit of the northern blocks described on a previous occasion (p. 11), and their further advance to the south in some situations than in others, is attributed to the form of the present continent of Russia in Europe, nearly all of which, it is presumed, was under the sea during the distribution of these boulders.

The authors adhere to the opinion previously expressed by them, that such blocks were transported to their present positions by huge floating icebergs, arrested, in some instances, by rising grounds and hills at the bottom of the then sea, and in others permitted to advance further south by longitudinal depressions, which are traceable in the present configuration of the land. Proofs are given that in many instances blocks of trap and quartz rock advance to quite as southerly latitudes as those of granite, and that all these blocks can be traced back to their parent rocks in Russian Lapland and the northern parts of Russia in a north-north-westerly direction, the currents by which they were transported having therefore been directed to the south-south-east. The black earth or Tchornoï Zem, which forms the highest deposit of the central and southern regions of the empire, has been described in a previous memoir (See *antè*, p. 5).

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A large geological map of Russia in Europe, coloured by the authors, and numerous sections and collections of fossils, illustrated this communication, and it was announced that other conclusions respecting the structure of Russia would follow the description of the Ural Mountains.

## PART II.

## ON THE URAL MOUNTAINS.

A SHORT introduction explains, that although the true geological relations of the rocks which constitute these mountains were previously little known, the Russians had become well acquainted with their mineral wealth and lithological structure. The skill and energy with which the mines have been worked having been adverted to, the authors dwell with pleasure upon the facilities which the Imperial Government afforded them by the instructions conveyed to all the mining establishments by the orders of Count Cancrine and the arrangements of Gen. Tchek'kine. They also acknowledge the advantages they derived from the co-operation of many officers at the different stations or zavods, several of whom prepared maps for their use\*. They further express their obligations to many individual proprietors, and notably to M. Anatole Demidof, and the Prince Butera, for their very hospitable reception at the zavods of Nijny Tagilsk and Bissersk. They then proceed to state, that without the small general map recently published by Baron A. von Humboldt and his associates, the objects of the journey could not have been so well attained. These objects were, to reunite the various fragments of the Ural chain, to show of what sedimentary masses it was originally composed, and to explain by what agency the strata have been dislocated and altered. In the latter respect they are aware that their labours have to a great extent been anticipated by the researches of Baron Humboldt, and his companions M. G. Rose and M. Ehrenberg, as well as by their predecessors Colonel Hel-

\* Among these officers allusion in this brief notice can only be made to those in command, viz. Gen. Glinka, Commander-in-chief at Ekaterinburg; Col. Völkner, formerly at Perm; Col. Protassoff at Bogoslofsk, who first explored the districts north of that station; Col. Tchaikofski of Ekaterinburg, and Col. Galahofski of Turinsk.

mersen and M. Hoffmann \*, and various officers of the Imperial School of Mines †.

Moving in two parties and upon separate but parallel lines of research, the authors examined both flanks of the chain simultaneously, their force being brought together at the chief establishments by mutual converging traverses; and thus, in less than three months, they acquired a general knowledge of the chain from Bogoslofsk on the north to Orsk and Orenburg on the south, a distance of about 550 miles. It is not pretended that this knowledge is precise in relation to the mineral structure of the mining tracts; as such details either have been or will be worked out by Russian engineers. The authors merely hope to have succeeded in giving *an unity of geological composition* to the chain, so that the age of the chief masses may be effectively compared with the unaltered deposits of the plains of Russia, and by this means with the geological succession of sedimentary deposits already established in Europe.

*Physical Features.*—Referring to Capt. Strajefski for his account of the northernmost and uncolonized part of the chain, which he explored amid great privations to 65° N. lat., the physical geography of the civilized portion is briefly sketched, and the chief altitudes, as determined by Colonel Helmersen, are given. The general bearing of the chain, as well known, trends from north to south. Ekaterinburg, the chief town, is situated on the eastern side of the only very low depression in the range, from which point this dividing crest between Europe and Asia rises both to the north and south, and attains altitudes occasionally of 2500 feet. The northern Ural, formerly occupied by Voguls, who still live in the wildernesses north of 61 degrees, is inhospitable in climate, and is chiefly occupied by dense forests, through which the rocks of the central water-shed are perceptible only at intervals. This monotony, however, is enlivened by knots of mountains which rise up on the sides of the parting ridge, and overtop it. Such are the Katch Kanar, the Pawdinskoi Kamen, near Bogoslofsk, 2784 English feet, and the Konjakofski Kamen, to the north of the same places, about 5700 feet above the sea ‡.

\* See various works on given districts of the Ural mountains by officers of the Imperial School of Mines.

† These works are referred to and ably condensed in a Russian work by Prof. Stshurofski of Moscow.

‡ This mountain was once estimated to have an altitude of 8000 or 9000 feet,

Whilst the North Ural (or that north of Ekaterinburg) has one persistent direction with some lower flanking ridges parallel to the chief one, the whole not occupying a breadth of more than from 45 to 70 miles, the South Ural, *i. e.* to the south of the mountain *Jurma*\*, expands to much greater width, branching off into fan-shaped ridges, which trend to the south and to the east and west of that point. In this region, however, as in the north, the water crest or *Ural-tau* preserves a north and south direction, varying in height from 1800 to 2500 feet, whilst the broken ridges on its western flanks, such as the Taganai near Zlataoust, rise to 3800 English feet, and the Iremel to about 5136 English feet above the sea.

From its configuration, and also from its latitude, the South Ural, inhabited by Baschkirs, is infinitely more picturesque than the North Ural; but, with the exception of the environs of Miask and Zlataoust, it is much less rich in mines than the North Ural.

*Geological Structure.*—The Ural mountains consist of ancient sedimentary strata, which, in the central parts of the chain and on its eastern or Siberian flank, are for the most part in a highly metamorphic condition; also of various rocks of igneous or intrusive origin.

Owing to the eruption of the latter at numberless points and along great zones of fissure parallel to the axis of the chain, the ancient deposits are so dismembered and altered, that it is at intervals only, they can be deciphered. The rocks are described in descending order, or from the flanks to the centre of the chain.

*Carboniferous System.*—By examining these mountains from their western slopes, where igneous rocks are comparatively scarce, the authors, in consequence of their knowledge of the palæozoic strata of western Europe and Russia in Europe, had no great difficulty in reading off the true order of succession on the banks of the Tchussovaya, Serebrianka, and other transversely-flowing streams. In the first place, the beds of sandstone, conglomerate and calcareous flags alluded to in the former memoir † are seen to rise from beneath

but by the trigonometrical observations of Fedoroff and the barometrical calculations of Kupffer, it has been ascertained that it cannot exceed 5280 Paris feet above the sea. It was upon this point of the range that the authors saw much snow in the month of July.

\* About 3000 English feet above the sea. All these heights are taken from Colonel Helmersen and M. Hoffmann.

† See *antè*, p. 14.

the Permian deposits, and containing in some parts thin courses of coal, and in others coal-plants, Goniatites and certain fossils, represent the upper members of the carboniferous system. These strata are succeeded by a thick formation of hard quartzose grit and sandstone, very much resembling the millstone grit of some parts of England. Beneath this is the carboniferous or mountain limestone, properly so called, of English geologists, and which is recognised by containing many of the same typical fossils as in England and other parts of Russia. Thus defined, the carboniferous system occupies, on the western side of the chain, a very wide zone, which to the south of Kongur is expanded into a large trough extending beyond the parallel of 55° N. lat., and flanked upon the west and east by upcasts of the limestone, it contains in its centre the great undulations of the grits and conglomerates just spoken of.

A third and less prolonged, but most remarkable zone of this limestone appears in four insulated hills extending north and south of Sterlitamak, and perfectly parallel to the chain. It is in the southern prolongation of this line of upheaval that the Permian red sandstones and limestones of Gre-beni and Orenburg are thrown into anticinal positions, the axis of which is also parallel to that of the adjacent older rocks. For reasons hereafter adduced, it is inferred that this anticinal was formed subsequent to the chief elevation of the chain.

*Devonian Limestones, &c.*—The Devonian rocks of the North Ural are seen on the banks of the Tchussovaya in the form of limestones, grits and schists, which pass into the lower carboniferous limestone, the latter being always in highly inclined, sometimes in very contorted and even inverted positions, the younger rocks dipping under the older. These Devonian limestones much resemble, in their dark colour and subcrystalline aspect, those of South Devon in England, and they contain fossils characteristic of this division both in the British Isles, in Belgium, Prussia and the Eifel; but though perfectly identified both by position and contents with the Devonian rocks of the flat regions of Russia, the Uralian strata are as dissimilar from them in external aspect as the rocks of the same age in Devonshire are from the old red sandstone of the north of Scotland and of Herefordshire or Brecon in England. Nor are these Devonian rocks on the western flanks of the Ural separated from the lower car-

boniferous limestone by any band of sandstone and coal as in the northern parts of Russia in Europe, but the grey limestone of the overlying group is at once succeeded by the dark limestone of the other, both undergoing the same flexures, and both forming parts of one great palæozoic series.

In their prolongation to the south, the limestones of this Devonian group thin out and inosculate with a considerable development of red sandstone, grit, fine conglomerate and schist, in some parts resembling the old red sandstone of the Highlands. A peculiar mineral character of these Devonian limestones is, that they retain their black colour even when in the state of dolomite.

*Silurian Rocks.*—The schists and flagstones which underlie these limestones are considered to be of Silurian age; with these strata are associated beds of limestone for the most part concretionary, and which are well developed on the banks of the Serebrianka from the zavod of Serebriansk to near its mouth. Among the predominant fossils of this group and amid numerous corals, the *Terebratula prisca* (*Atrypa affinis*, Sil. Syst.) is clustered together in great masses, as in the Ludlow rocks of England, and with it are associated the remarkable *Leptana Uralensis* and other new species. The same descending sequence cannot be so well seen in many parts of the North Ural, as on the banks of the Serebrianka.

Immediately, however, to the east of the watershed (viz. from Bogoelofsk to Nijny Tagilsk and Neviansk), broken masses of limestone, insulated amid plutonic rocks, are charged with large *Pentameri*, closely approaching to the *Pentamerus Knightii* of the upper Silurian rocks, and associated with *Orthis*, *Terebratula* and other fossils, which, from collections sent to him, M. de Buch has classed as Silurian forms (see *Beiträge der Geb. Form. in Russland*. Von L. Von Buch. 1840). Although then the clear stratigraphical sequence is interrupted, there is no doubt that the equivalents, at least of the upper members of the Silurian rocks, exist in these mountains; and in tracing such into the South Ural, particularly by a transverse section from Verch-Uralsk to Sterlitamak, the authors convinced themselves, from the presence of *Orthidæ*, *Pentameri*, &c., that where not much interfered with by intrusive rocks, the central deposits of the chain (usually however in the

state of slate and quartz rock) belong to the Silurian system, and probably to its lowest divisions.

The symmetry which is developed on the western side of the water-shed is almost obliterated to the east by the greater frequency of eruptive matter and the abundance of metamorphic and metalliferous rocks. Thus in passing eastwards into Siberia on any parallel, from Bogoslofsk, Nijny Tagilsk, Ekaterinburg, Miask or Verch-Uralsk, no regular succession can be traced; as large zones of igneous and crystalline rocks intervene, and thus different members of the palaeozoic series are met with upon the same strike. In some spots however, notwithstanding all this confusion, transitions can be traced from lower to higher formations. At Bogoslofsk, for example, a passage may be observed from Silurian to Devonian strata; and though all the formations are not in apposition to the east of Ekaterinburg, the section of the river Isset clearly shows, that, after various undulations, the Devonian limestones and schists on the west are succeeded on the east by true carboniferous limestone with large Producti, this latter deposit being in some instances based upon conglomerates and grit. Whilst this succession is exposed in a region penetrated by many points of eruptive trap and porphyry, the whole of the less altered group reposing on micaeuous schists and other granitic rocks, a mass of Pentamerus limestone, is thrown up in an insulated tract at a small distance; and as this limestone is quite dissimilar from any visible in the adjacent gorges of the Isset, where the Devonian and carboniferous limestones are fully developed, the authors conclude that it belongs to the Silurian epoch.

On the eastern flank of the southern Ural the ancient sedimentary rocks occur in great undulations. At Troitsk in the steppes of the Kirghis, or beyond a chain of granite separated from and parallel to the Ural (see map), Silurian and Devonian limestones occur, whilst at Cossatchi Datchi, close to the eastern flank of the Ural, there is a small basin of palæozoic rocks, the limestone of which is proved to be true carboniferous, by containing a vast profusion of fossils, many of which are common to the Waldaï limestones of Russia, and the mountain limestone of the British Isles and Belgium. In following southward the eastern slopes of the chain

where they border on the river Ural, promontories of carboniferous limestone rise up in undulations, supporting troughs of the coarse carboniferous grits and conglomerates before alluded to; and on passing the axis of the chain between Orsk and Orenburg, where it dwindles to a small height, the same carboniferous group of limestones, conglomerates and grits is thrown off to the west upon the face of the igneous rocks forming the Guberlinsk hills. In travelling westwards to Orenburg, particularly from the limestone hills of Gourmaya, the authors found a most instructive section, developing the ascending order from the great carboniferous limestone through the overlying grits, flagstone and calcareous grits with Goniatites, into the beds with gypsum, which form the base of the Permian system, the whole being distinctly overlaid by conformably inclined strata of cupriferous grits, red sandstone, shale and limestones containing fossils of the zechstein.

Upon the eastern flanks of the Ural, on the contrary, granitic and other igneous rocks rising (as before said) to the surface, that region is entirely void of all those strata which in Russia in Europe are interposed between the carboniferous and Jurassic systems. Beds belonging to the latter system have indeed been detected at two very widely distant localities, the one in 65° N. lat. by Capt. Strajefski, the other forming a plateau in the southernmost extremity of the chain north of Orsk, where they were first observed by Col. Helmersen\*. It must however be observed, that the great mass of the chain is void of Jurassic strata, nor have its eastern flanks afforded any evidences of cretaceous or tertiary rocks, as identifiable by organic remains. From this last remark, the authors would except certain grits which occur in patches in the lower country of Siberia, notably at Kaltchedansk, east of Ekaterinburg. These grits, which are largely quarried for millstones, might almost be called "trachytic," as they resemble in composition some of the rough trachytes of Hungary, and like which they pass into an impure pitchstone grit. From the associated amber and beds of clay, it may however be inferred, that

\* The authors did not visit the last-mentioned spot, but, from the communication of their friend Colonel Helmersen, they have little doubt that this deposit is a fragment of the Jurassic range which they traced to the south and west of Orenburg.

these rocks were formed under water, and that they owe the trachytic aspect to their having resulted from the detritus of the quartzose porphyries on which they repose. They are probably continuous masses of the grits described by G. Rose, near Verkhoturie. Sections on the river Isset explain these phenomena.

*Igneous, Metamorphic and Metalliferous Rocks.*—As it formed subordinate parts only of the objects of the authors, either to study the details of the metamorphism of the sedimentary strata produced by the intrusion of igneous rocks, or the associated simple minerals, the relations of both of which have been so elaborately described by M. G. Rose, this portion of their memoir is chiefly confined to a sketch of some striking phenomena of this class. No true granite appears in the higher mountains, the syenite which is seen at intervals being intimately allied to greenstone; and the latter, with its various modifications, is by far the most abundant of the intrusive rocks which appears on or along the immediate flanks of the Ural ridge\*. Whenever these greenstones and traps rise to the surface, the strata in their proximity are highly altered. Thus even when studied on a small scale on the western flank of the mountains, as at the baths of the Zavod of Sergiesk, the sandstone in contact is altered into quartz rock, and the limestone so regularly bedded and full of fossils at a little distance, is converted into an amorphous, crystalline, splintery mass, charged with cross veins, and sulphureous saline waters flow from its base, the adjacent rocks being also much impregnated with iron ore. Similar but on a far grander scale are the phenomena of intrusion and metamorphism which are presented by the central axis of the Ural, and to a less extent by all the parallel ridges which flank it on the eastern or Siberian side.

The Ural-tau or crest is to a very great extent a wall of schist and quartz rock diversified by points of igneous rocks, and though of no great altitude, it is very remarkable that throughout 17 degrees of latitude this water-shed is not broken through by any great transverse valley. The Ural-tau marks, in fact, one long line or fissure of eruption. With the exception of the gold mines near Bissersk, on its west flank, all the gold alluvia of the chain occur

\* The granitic region is in Siberia, to the east of the Ural.

on its eastern flank; and when it is stated that this circumstance is connected with the fact, that all the great masses of igneous rocks have been evolved on the eastern flank, it will at once be seen (as insisted upon so well by Humboldt) that there is an intimate connexion between the eruption of plutonic rocks and the formation of the gold mines whence the local alluvia have been derived. That this connexion exists in regard to other mineral veins, is also equally apparent in the Ural mountains, for with very rare exceptions, it is only on their eastern or eruptive side that copper veins, malachite, platinum and magnetic iron prevail \*.

Without entering into all the lithological distinctions of the North Ural, they advert specially to the occurrence in the districts of Turinsk and Nijny Tagilsk of a stratified and regularly bedded porphyry, which they compare with the "Schaalstein" of German geologists, and which on the banks of the Kakwa and east of Bogoslofsk†, as in the Rhenish provinces, alternates with limestone strata of Devonian age. In the copper mines of Turyinsk, the veins and masses of ore are shown to be intimately connected with the intrusion of greenstone, between a thick mass of which and the metalliferous veins is a garnet rock. This phenomenon is a counterpart to that formerly described by Professor Henslow in the Isle of Anglesea; whilst on the river Kakwa, the ordinary limestone (Devonian?) has been converted by a dyke of greenstone into white granular marble, in the same way as by the contact of syenite the lias limestone of the Isle of Sky has been changed.

The Katch-kanar mountain (lat.  $58^{\circ} 44'$ ), which the authors visited by a little-frequented pass, is composed of augitic greenstone and magnetic iron, the latter in so hard and crystalline a state that it is not worthy of extraction and manufacture. The most productive masses of magnetic iron are at the Government establishment of Mount Blagodat, and that of Nijny Tagilsk, belonging to M. Anatole Demidoff. In both these cases the ordinary varieties of iron occur in great masses, occasionally with chromate of iron ‡, in

\* In sketching the chief relations of the plutonic and metamorphic rocks of the North Ural, much praise is given to a detailed geological map of the environs of Bogoslofsk by Capt. Karpinski, of the School of Mines, with a copy of which the authors were furnished.

† See Geol. Trans. vol. vi. pp. 246, 248.

‡ The largest masses of chromate of iron occur in the South Ural, near

contact with rocks of igneous origin, in which serpentine, compact felspar, greenstone, porphyry, &c. are apparent. At Nijny Tagilsk the chief intrusive rock (greenstone) is coated by prodigious masses of the iron ore, which is worked in open quarries, and is most magnetic where it is in contact with greenstone. Copper ores also abound at this spot, and some of them are associated with Silurian limestone, often highly mineralized, but in which large Pentameri and other fossils are observed; also with a bedded trapporean rock or schaalstein, which is in parts highly cupriferous. It is from such ancient rocks that copper solutions are supposed to have flowed, in very remote periods, into the adjacent low countries on the west, then under the sea, and to have impregnated the sandstones and grits of Perm during their formation. The malachites of this place have long been celebrated, and, from their structure as well as their position, in cavities of the rock, they are supposed to have been formed by ancient stalactitic depositions. The ores of platinum, though hitherto found in alluvia only, always occur near the intrusive igneous rocks. Magnetic iron ore and copper ore are stated to occur at many other localities, and always under similar circumstances.

*Gold Ores.*—Though the great supply of gold which the Ural mountains afford, is derived from alluvia, the ore has been found in veins which are slightly worked at Berosofsk, near Ekaterinburg, and were formerly near Miask\*. Wherever gold veins or gold alluvia have been discovered, the auriferous matter is flanked by rocks of intrusive origin, and these are very frequently serpentine. It has however been shown by Humboldt and Rose, who, in the first volume of their recent work, have described twenty-seven sites of gold alluvia in these mountains, that the auriferous detritus rests upon a great variety of rocks, viz. talcose, chloritic, siliceous, argillaceous schists and encrinite limestone, as well as upon granite, greenstone and serpentine, though most frequently on the

the mines of Polikofski, south of Miask, and from whence from 6000 to 7000 "pounds" per annum have recently been sent to Moscow.

\* In the tracts around Miask and Zlataoust the authors were most cordially and judiciously assisted by General Anosof, an officer highly distinguished for the metallurgic processes and the manufacture of small-arms which he directs. His assistant, Major Lissenko, who has prepared a mineralogical map of the surrounding country, was also kindly serviceable to them.

last-mentioned rock. An observation also of these authors is important, as bearing upon the relative date of the origin of gold, viz., that the veins containing it have been seen by them to cut through not only the schists and the beresite (according to them a felspathic granite), but also the serpentine; thus seeming to prove that the gold veins have resulted from one of the very last changes which have affected this region. (Rose, vol. i. p. 422.)

It is stated, that as the alluvia containing gold are purely of local origin, or derived from the adjacent hills, their accumulation can have no reference to the actual period, and present rivulets or waters, for the deposits lie at considerable heights above their beds, contain bones of mammoths, the extinct rhinoceros, and, in some instances, are even traceable over small ridges of intrusive and altered rocks from veins whence the detritus was doubtless derived, and accumulated in its present state at the period when the large mammals were destroyed. Numerous sections are given at Berosofsk, Soimanofski Zavod, and notably from the environs of Miask and Cossatchi Datchi, all of which tend to establish these views, as well as those of the alteration, mineralization and crystallization of the paleozoic strata by the intrusion of igneous matter, and prove that the alluvia were collected anterior to the existing epoch. Some of the gold alluvia are exclusively composed of carboniferous limestone replete with fossils (Cossatchi Datchi).

In concluding this sketch of the Ural mountains, the authors advert to the remarkable fact, that all the superficial detritus is local, and that no large boulders or blocks transported from afar are visible either in the chain or in the low countries on its flanks; and they also state, that they nowhere observed among the higher portions of the mountains any traces of those scratches or polishings of the rock which are common in some parts of Europe, and which are supposed to have been produced by glacial action.

Original maps and sections of the districts around the mining establishments of Bogoslofsk, Turinsk and Blagodat Ekaterinburg, Soimanofsk, Zlataoust and Miask, prepared by the officers of the Imperial School of Mines, were exhibited, as well as a map of the North Ural to  $65^{\circ}$  N. lat., drawn by Strajefski, together with a most elaborate geographical map of the South Ural, executed by orders of General Perovski, under the superintendence of the officers of

the staff of his government, directed by General Rakosofski\*. From all these documents and others published in the volumes of the 'Journal of the School of Mines,' combined with their own observations, the authors have coloured geologically the map of Humboldt, a reduction of the chief features of which will appear in a map now in progress, which will accompany their forthcoming work on Russia and the Ural mountains.

*General Conclusions.*—In greatly extending the knowledge which they had previously acquired, the survey of last year has enabled the authors to modify their earlier views concerning the equivalents of some of the strata of Russia in Europe. With respect to their former account of the great tripartite palæozoic series of beds which covers such large portions of Northern Russia, they have nothing to retract. On the contrary, by adding to their previous lists a great number of typical organic remains well known in Western Europe, they are still more convinced of the accuracy of their first classification, and of the existence of large zones of Silurian, Devonian and carboniferous rocks, clearly separated from each other by their order and their imbedded fossils.

The newly discovered dome of Devonian rocks in the centre of European Russia is a feature of great importance, in explaining the difference between the mineral basin to the north and that to the south of it. The carboniferous system, the most widely extended deposit of Northern Russia, has now been subdivided into stages, each characterised by its fossils; and it has been clearly shown, that the most productive of the coal-bearing strata in the Russian empire, viz. those of the southern steppes, are associated with the mountain limestone, whilst the uppermost member of the system, or coal-measures, which is so rich in coal in Western Europe, if indeed it exists, is nearly unproductive in Russia.

The next great group of rocks in ascending order, is that which has been elaborated in considerable detail under the name of the Permian system, and which, as already shown, is to be considered as a vastly expanded equivalent of the zechstein and associated beds of Germany and the magnesian limestone of the British Isles. This

\* This map is illustrated by a description of the physical features of South Ural from the pen of M. Khanikof, which Mr. Murchison has communicated to the Royal Geographical Society of London.

system is rendered much more important by its fossil contents in Russia than by any remains which have been discovered in it in other parts of Europe ; for not only does it contain, like the zechstein of Germany and the magnesian limestone of England, the remains of thecodont saurians and certain fishes (Palæonisci), but also a fauna much more copious in other classes, and a flora infinitely more rich than any which had been previously made known as pertaining to rocks of this age. This flora is shown to be of intermediate characters between that of the carboniferous system and the plants which have been published as typical of the trias.

The Permian system is also of high interest in setting before us the example of wide accumulations impregnated throughout great thicknesses with copper, and as this matter has manifestly been derived from the mineral masses of the adjacent Ural, so is it inferred that these mountains constituted dry land on which the plants in question grew, and that the latter having been washed down into these Permian deposits were there rendered the nuclei of the copper ores which are arranged around them. The thin layer of kupfer schiefer of Germany may be considered as the miniature representative of this great metalliferous deposit, whilst in its large masses of gypsum, the Permian deposits exceed even the zechstein on the south of the Hartz\*. The Jurassic system of Russia reposes on the Permian and older rocks without clear evidence of the existence of any part of the Triassic group, there being no traces of the muschelkalk limestone nor yet of the keuper ; and it is with doubt even that the authors refer any portion of certain red strata which partly overlie the Permian rocks to the "bunter sandstein," or new red sandstone of geologists.

True lias has not yet been seen, but the Jurassic system is clearly divisible into upper and lower formations, and is followed by the cretaceous and tertiary systems, the latter including eocene, miocene and pliocene shells, and all these groups are copiously developed and clearly recognisable by their respective mollusca.

The geological survey of the flat regions of Russia, add the

\* The authors use the term "Permian" in reference to Russian deposits only, and they by no means seek to interfere with the general use of the word "Zechstein," which has been so long sanctioned by the highest German authorities.

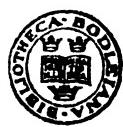
authors, in affording the best proof which has yet been obtained in any part of the world of *the same extent*, that distinct forms of animal life were successively created and entombed in each succeeding deposit, has also demonstrated that the successive obliteration of these classes was not caused by the outburst of contiguous plutonic rocks or great physical disturbances of the strata; for in this region, as large as the whole of those districts of the continent of Europe where geology has been most studied, no intrusive rocks are visible, and the wide-spread formations from the Silurian to the youngest tertiary, which must have occupied so vast a lapse of time in their accumulation, as well as the beds of retired modern seas, all repose conformably upon each other. And yet with this regular sequence throughout so vast a series and the absence of any great ruptures, the contents of each succeeding system of older strata are as clearly separable from each other as in those parts of the world where younger rocks are incumbent on the uplifted edges of those which had been previously dislocated.

But whilst they offer no traces of great and violent upheavals, the horizontal rocks of Russia bespeak most clearly that their surface has been so far acted upon by elevatory or subsiding movements, that in some tracts great thicknesses of strata are omitted. Bounded as this large geographical basin has been in remote epochs by the plutonic eruptions of Lapland and Sweden on the north, of the Ural on the east, of the granitic steppe on the south, and of the trappean rocks of Poland and Silesia on the west, it is possible, however, that the changes which were evolved in these regions may have affected and influenced the distribution of animal life in the great Muscovite depression which they surrounded. As every geological phenomenon in the strata of the plains of Russia indicates a submarine succession, so does the surface announce the same conditions. In the far northern districts the bottom of the Arctic Sea has been shown, by the presence of many existing species of shells, to have once extended over a wide tract of land, now 150 or 200 feet above the sea-level; and in the south-west it is known by like proofs that the Caspian once covered still wider districts of the steppes. Again, the authors have endeavoured to show that the mammoth alluvia, the boulders of the North and the black earth of Central and Southern Russia, have all been accumulated *under water*.

In reference to the question of the transport of the northern blocks, the authors conceive that their last survey has tended very materially to strengthen the opinions which they previously expressed, that such materials were carried to their present positions by floating icebergs liberated from ancient glaciers in Scandinavia and Lapland, at a period when Russia in Europe was submerged. The examination of the Ural has in the meantime convinced them of the utter inapplicability of a terrestrial glacial theory even to all mountainous tracts of the earth ; for these mountains, the peaks of which rise to upwards of 5000 feet above the sea, though situated in so cold a climate as to be now covered with snow during eight months in the year (and some peaks are never uncovered), show none of those signs insisted on by glacialists, of their having been at any period the residence of permanent glaciers. With the total absence of such proofs, so it is a striking confirmation of the connexion between glaciers and the blocks which in Russia in Europe are supposed to have been floated from Scandinavia and Lapland, that the flanks of the Ural chain and the adjacent plains are entirely void of all such far-transported detritus\*.

\* The authors announced that the geological map of Russia and the Ural, as taken from their larger documents, would be published in a short time, and that their work descriptive of all the phænomena alluded to in these notices would be prepared in the ensuing winter.

THE END.



PRINTED BY RICHARD AND JOHN E. TAYLOR,  
RED LION COURT, FLEET STREET.

